Implied Ocean Heat Transports in the MMF

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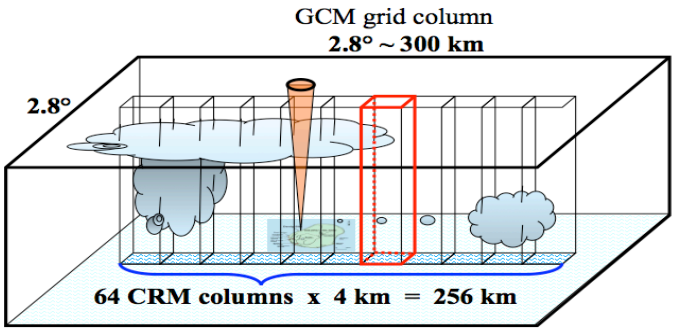
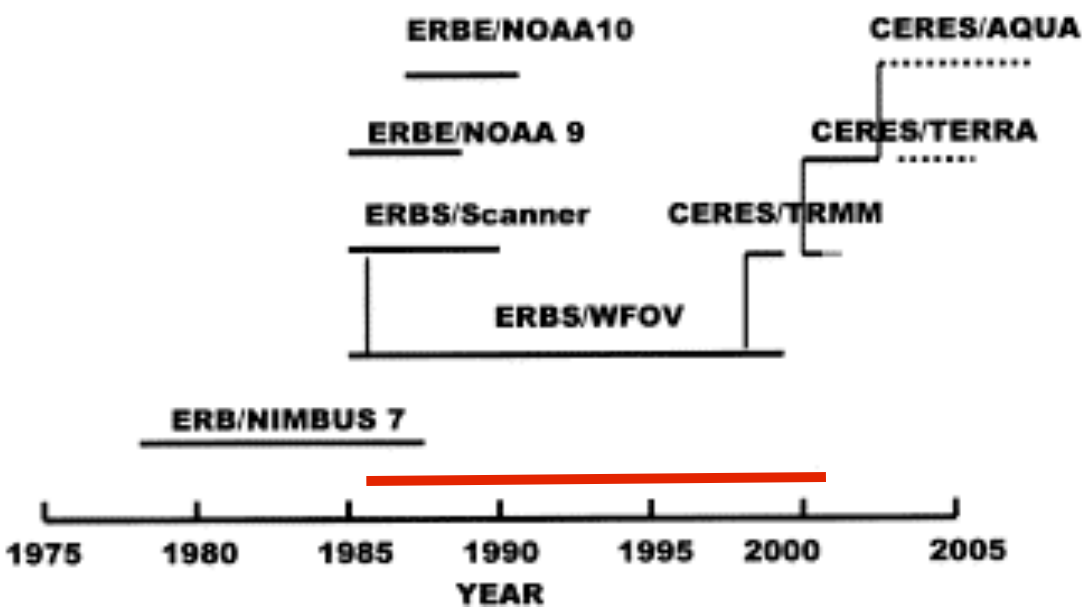
The Simulations

- NCAR Community Atmospheric Model, v3 (CAM3)
- CAM3, but with cloud resolving model (MMF)
- AMIP-style simulations (lower boundary is observed SSTs)
- 1986-2001



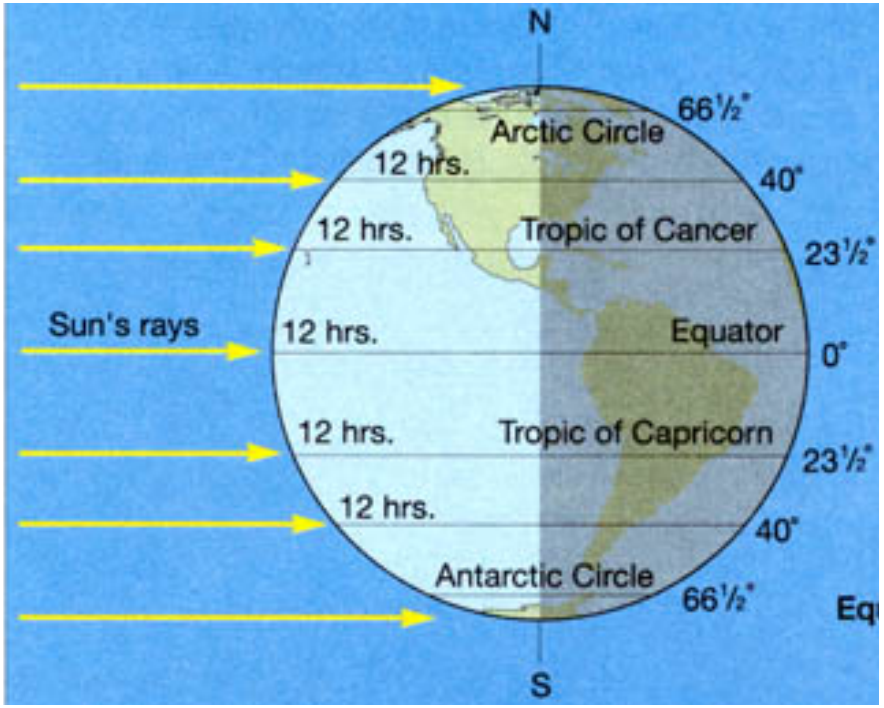


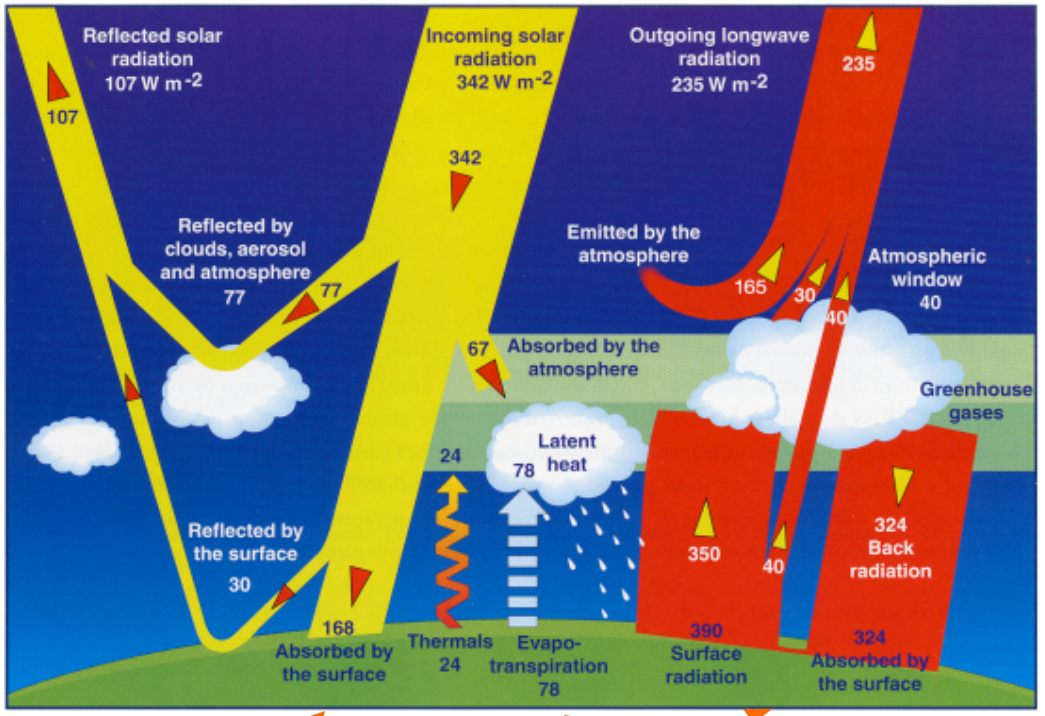
timeline plot from Smith et al., 2003

Why Ocean Transports?

- A simple way to examine the net effect of atmospheric model errors on the simulated climate.
- Each term (SW, LW, SH, and LH) can be evaluated for its contribution to T_o error.
- Errors in each term may be traced to specific regions or processes.
- Reducing the largest errors is the most direct route to an improved simulation.

Calculating Ocean Transports

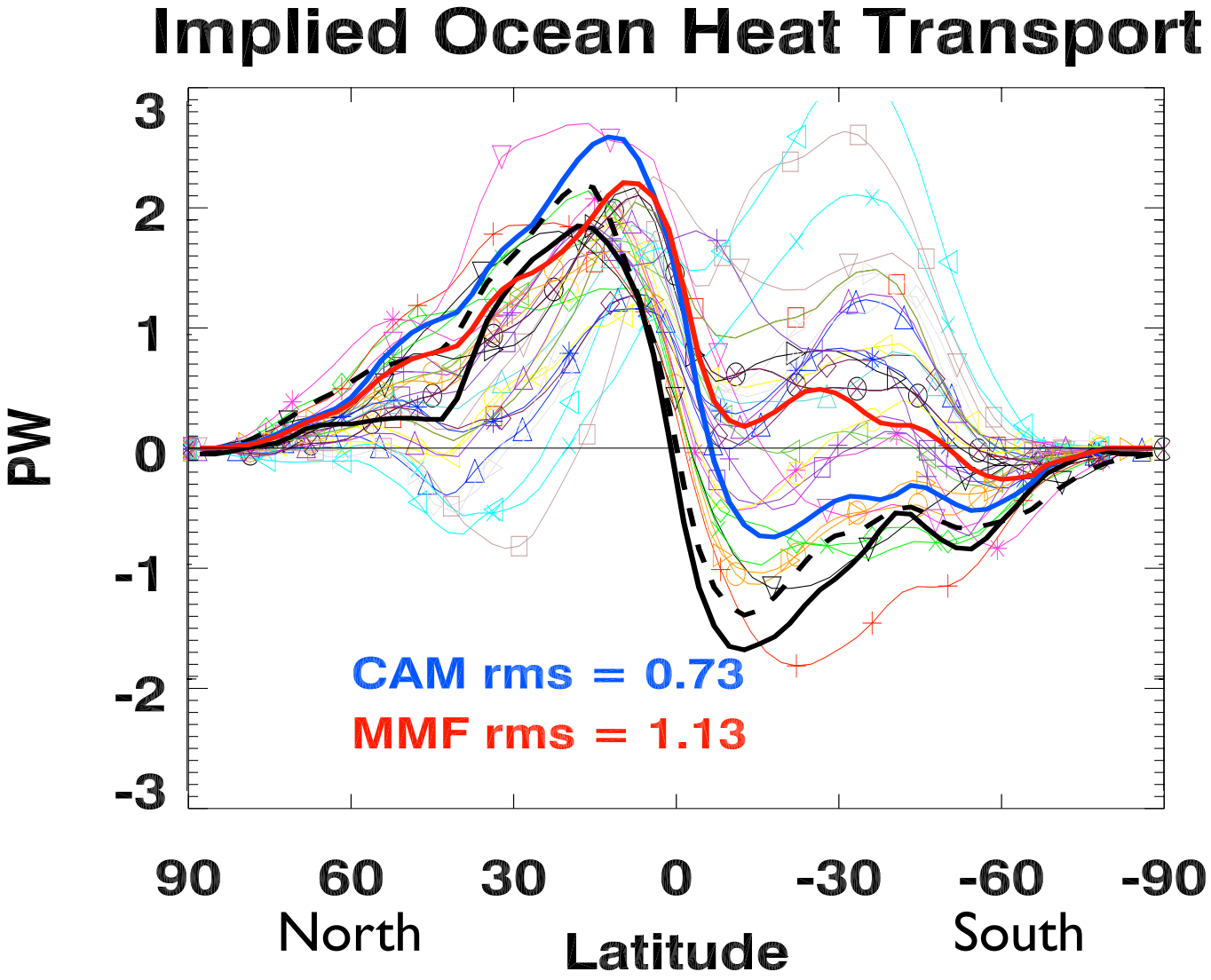




net surface energy = SW + SH + LH + LW

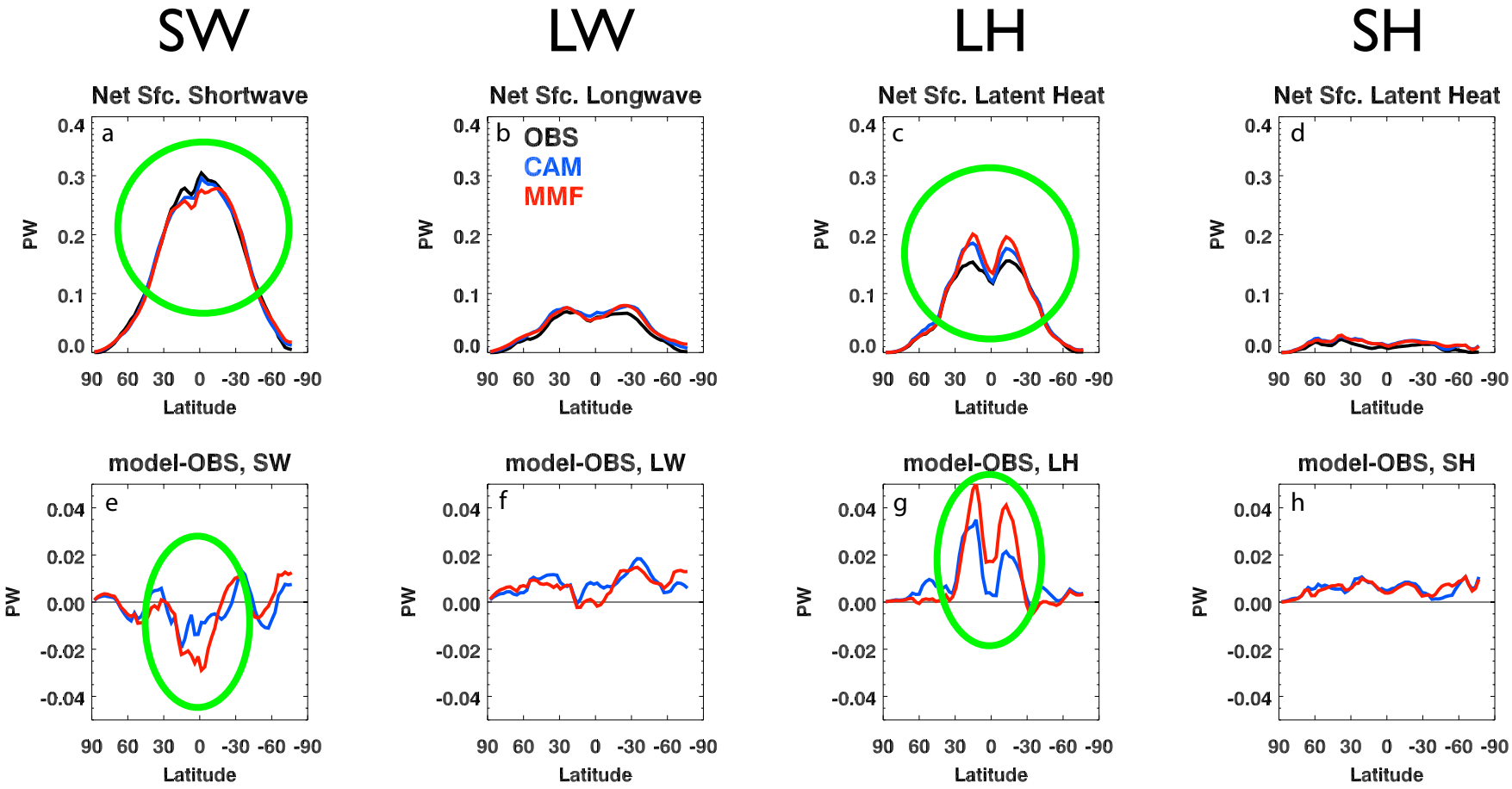
- net surface energy is computed over ocean surface
- for each latitude band, ocean transport is required to offset energy surplus or deficit
- implied ocean head transport calculated by integrating net surface energy from SP toNP

T_o in CAM, MMF, other models



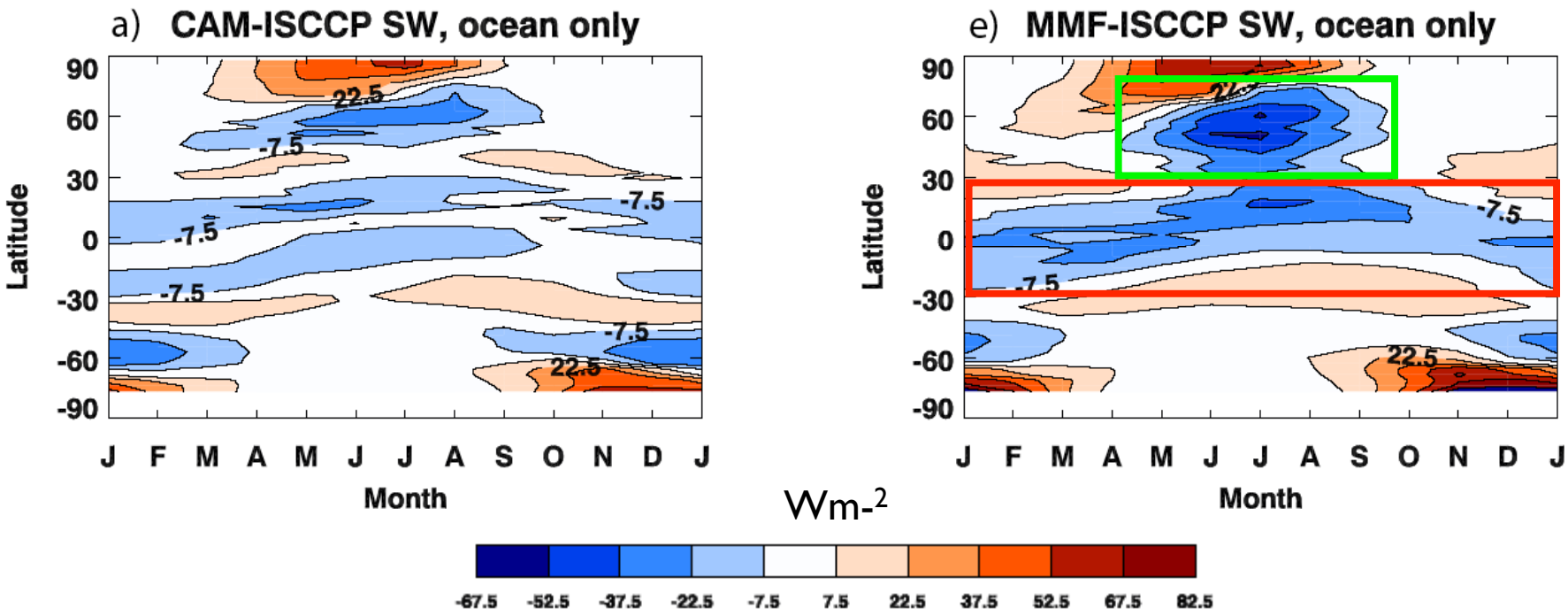
additional data from Gleckler et al., 1995

Surface Energy Errors in CAM, MMF



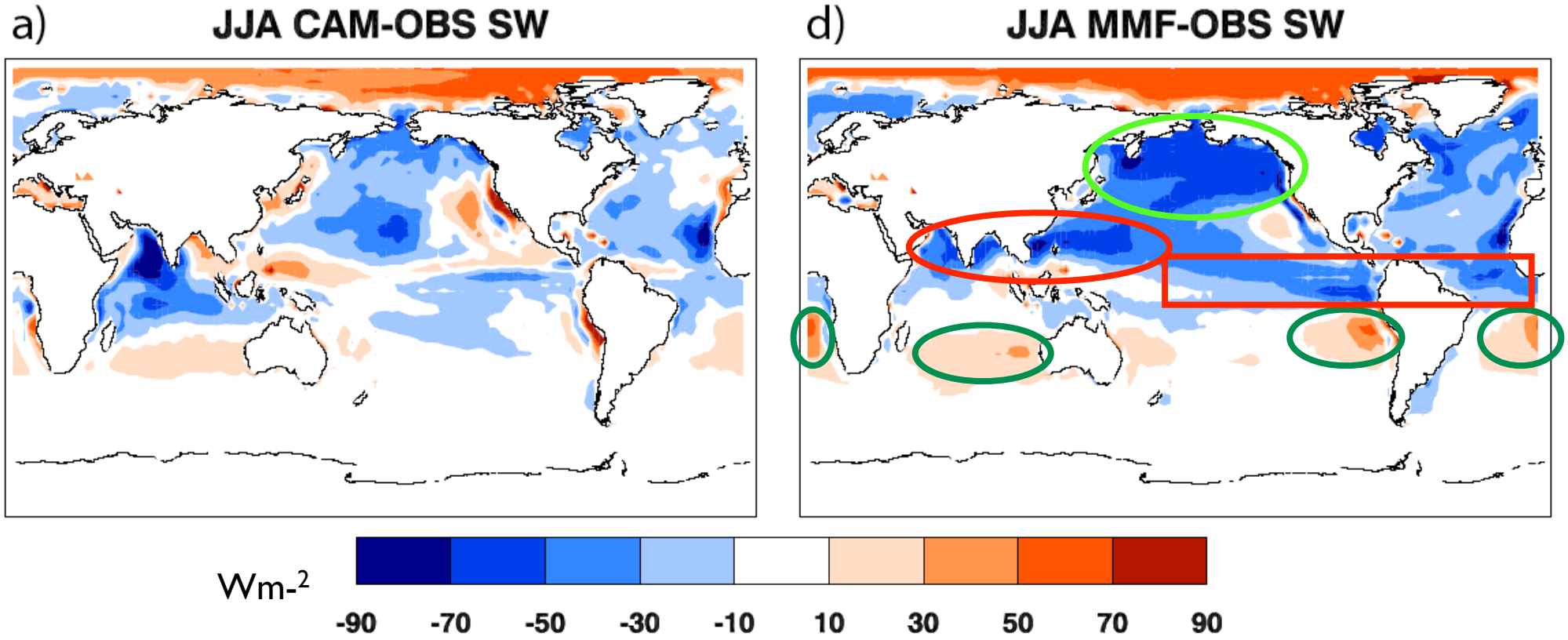
- SW and LH are largest components of surface energy budget
- SW and LH are also largest error sources

Surface SW Errors in CAM, MMF



- Largest MMF SW errors associated with ITCZ
- Summertime negative bias in Northern Hemisphere

Surface SW Errors in CAM, MMF

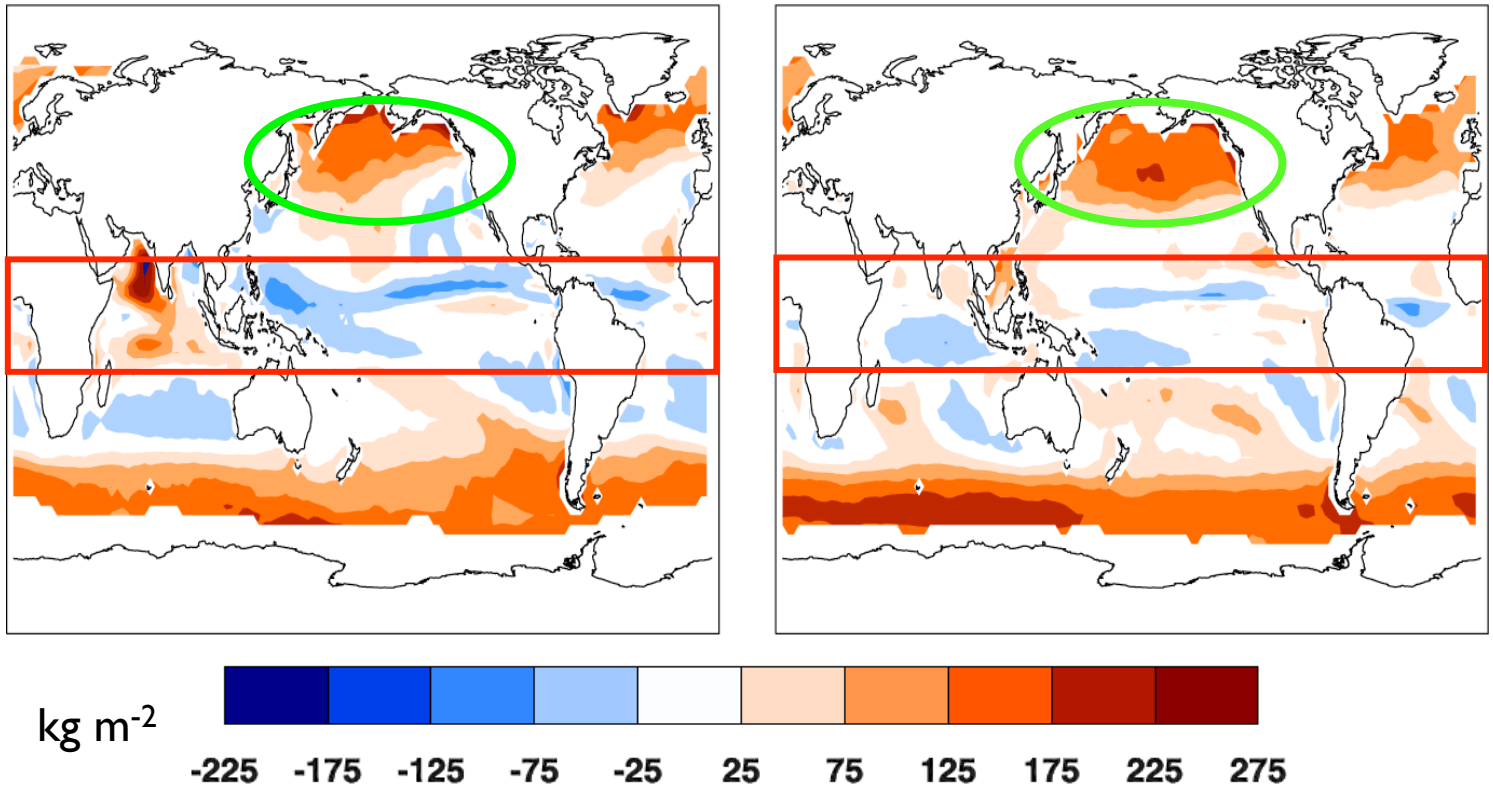


- Deep tropical convection (Asian monsoon, ITCZ)
- SH marine stratocumulus clouds
- North Pacific

Liquid Water Path in CAM, MMF

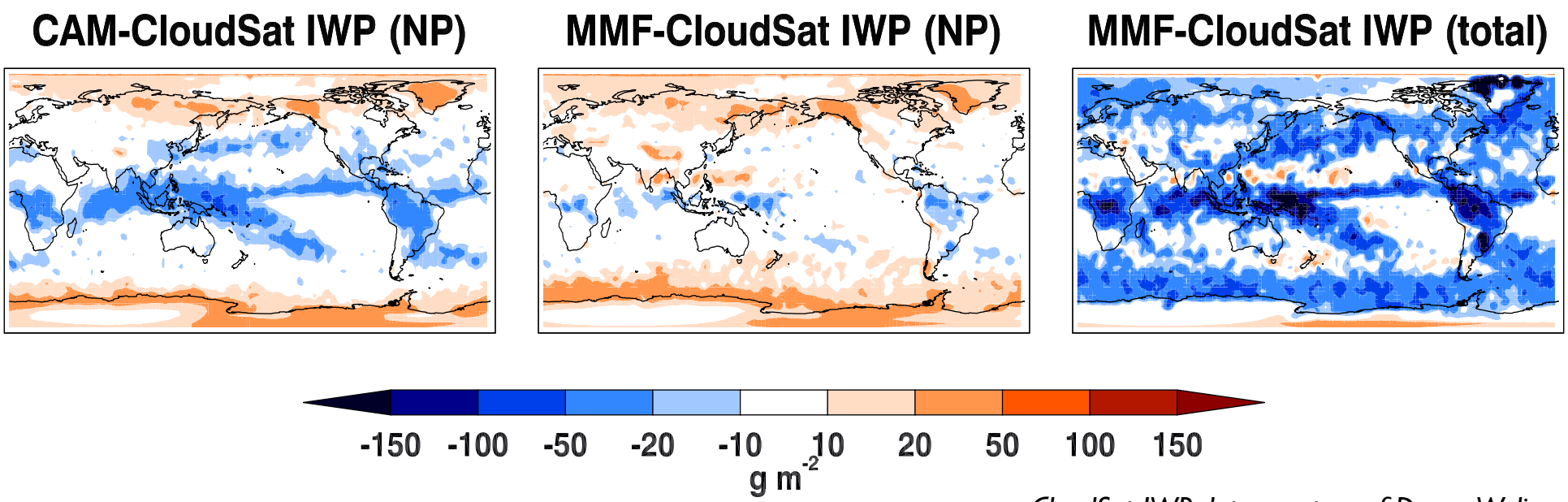
CAM-ISCCP (JJA)

MMF-ISCCP (JJA)



- Tropical LWP improved over CAM
- North Pacific LWP greater than in CAM

Ice Water Path in CAM, MMF



CloudSat IWP data courtesy of Duane Waliser

- MMF has greater IWP in ITCZ than CAM
- MMF North Pacific IWP greater than in CAM

MMF Convective Ice Bias

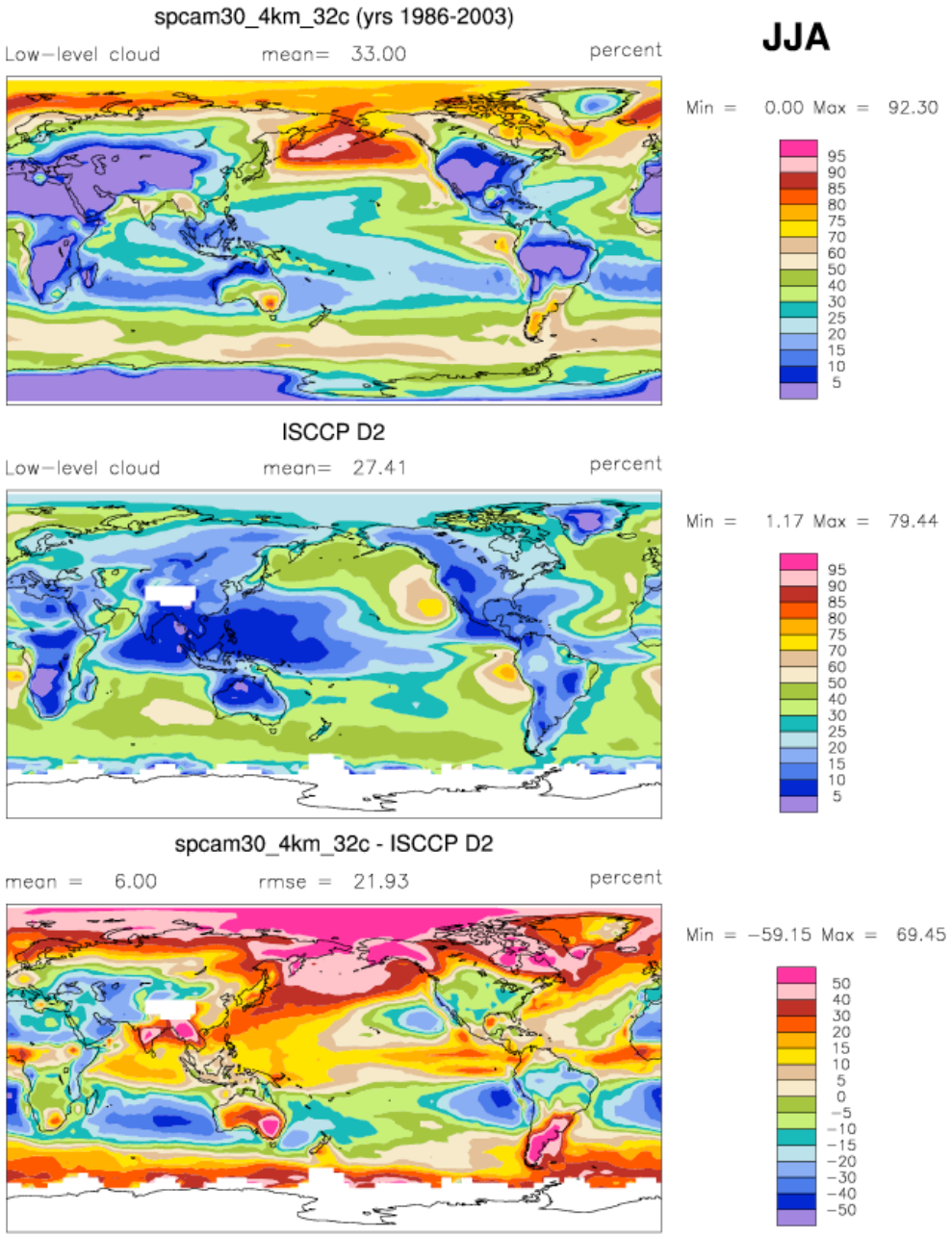
- Possible causes
  - insufficient settling or precipitation of ice
  - overly vigorous convection
  - improper ice crystal size distribution?
- Potential remedies
  - improvement of ice microphysics
  - 3D embedded cloud resolving model?

Marine Sc clouds: seasonal mean

MMF

ISCCP

MMF-ISCCP



- MMF under-predicts marine Sc clouds

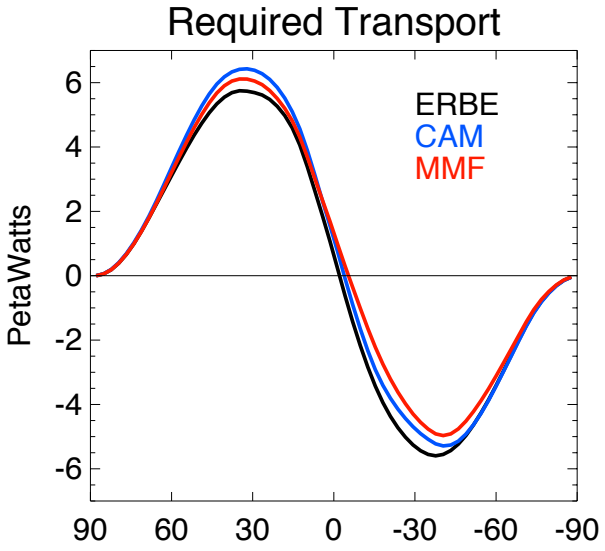
MMF Marine Sc Cloud Bias

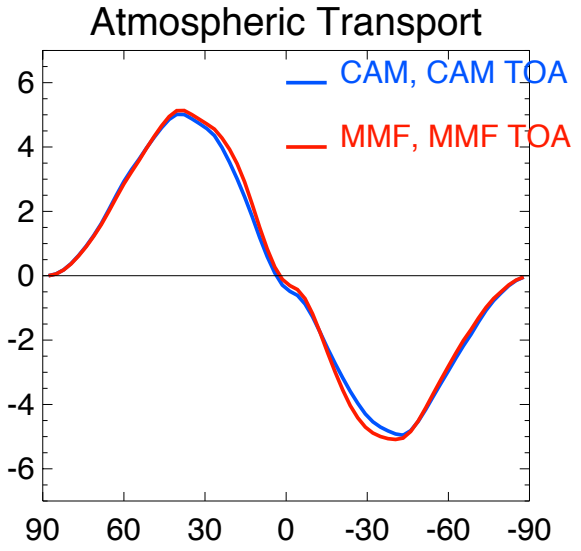
- Possible causes
  - imbalance between surface fluxes and cloud-top entrainment
- Potential remedies
  - finer vertical and/or horizontal resolution of embedded CRM?

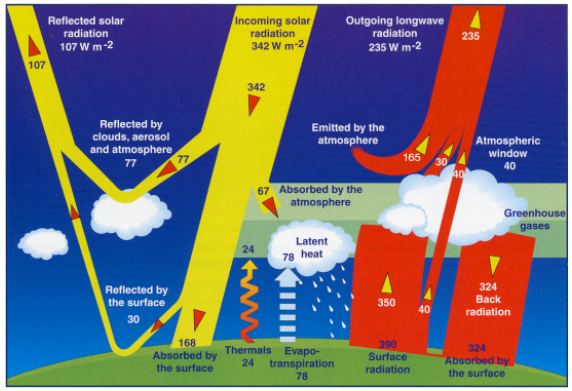
Effects of Cloud Improvements on T_0

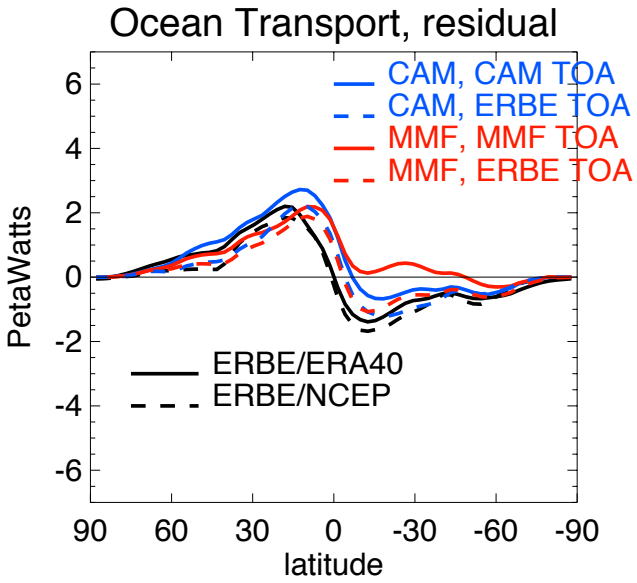
- Assume that model improvements lead to better representation of tropical convection and marine Sc clouds.
- How might this affect the implied transports?

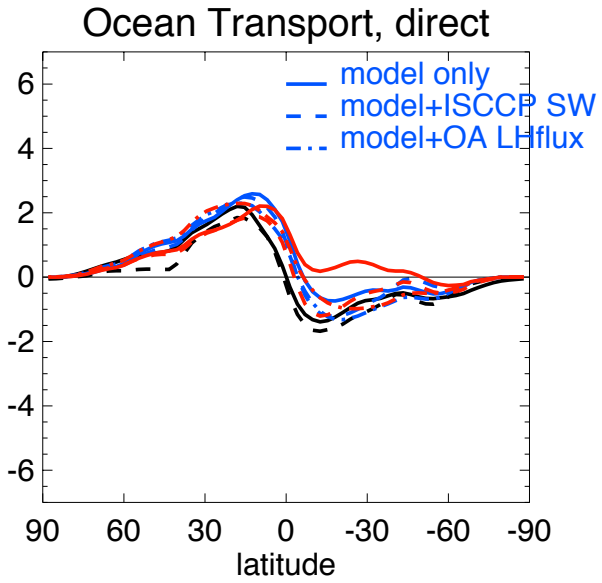
How to incorporate ERBE/CERES data?



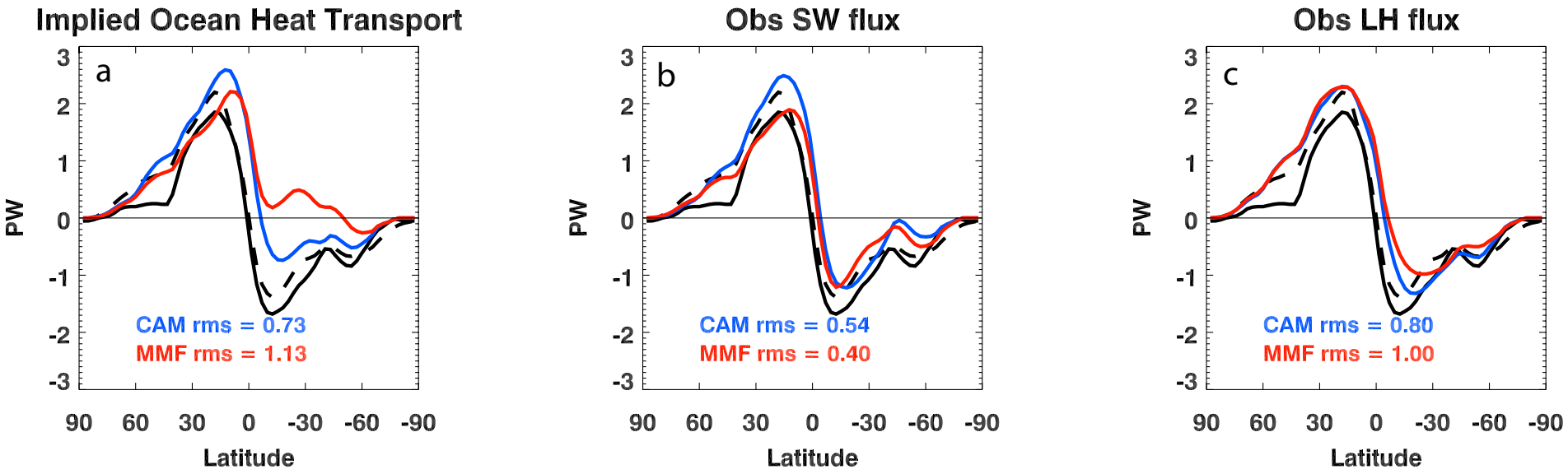








Impact of potential fixes on T_o



- Greatest improvement seen with observed SW
- LH improvements also improve T_o

Summary

- CAM3 and MMF surface energy budgets imply different oceanic heat transports from each other and from observations.
- Surface shortwave and latent heat fluxes account for the largest errors.
- MMF SW errors are primarily linked to tropical convection and marine Sc clouds.
- Observational TOA & Sfc radiation datasets help identify areas of needed improvement and provide estimates of magnitude of potential model fixes.